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ABSTRACT

Benkova, Dolginov, and Simonenko have recently reported the presence of "intermediate size" magnetic anomalies in the data from COSMOS-49 and hypothesized a crustal and/or upper mantle origin. We have examined the spherical harmonic models of the internal potential function, based on the OGO-2, 4, and 6 data (POGO(10/68) and later models), and verified the locations and amplitudes of those anomalies whose wavelengths approximate 4000 km. The comparison was made by subtracting a field model developed with a truncated series of $n^* = 9$ from one computed with $n^* = 11$ and generating a residual map equivalent to the COSMOS-49 data. The patterns of ΔF so computed from POGO were then compared with the IZMIRAN maps and also were analyzed statistically, in both the spatial and frequency domains, using residuals computed from the raw COSMOS-49 data with the $n^* = 9$ COSMOS-49 field model as reference. The two sets of data were thus derived from completely independent sets of observations and field references. The two patterns are shown to agree very well over the whole earth surface up to the 50° latitude limit of COSMOS-49.

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THE DETECTION OF "INTERMEDIATE SIZE" MAGNETIC ANOMALIES IN COSMOS-49 AND OGO-2, 4, 6 DATA

INTRODUCTION

The U.S. Geological Survey and Goddard Space Flight Center (NASA) are jointly involved in an analysis of presently available magnetic data from the COSMOS-49 [1] and OGO-2, 4, and 6 (POGO) [2] satellites. One major objective of this analysis is the identification of anomalies with possible lithospheric origins.

The signal associated with lithospheric anomalies at satellite altitudes has been estimated to be of the order of tens of gammas by upward continuation of regional aeromagnetic maps [3]. A signal of this amplitude is comparable to time variations of external sources, therefore satellite data must be obtained when the field is undisturbed. Also, the rapid decay of the signal with altitude requires that measurements be obtained at as low an altitude as possible. To obtain such data, the POGO observations, obtained during a period of variable magnetic activity and over an altitude range of 400 to 1500 km, had to be screened for low altitude and minimal magnetic activity. The number of POGO observations is great enough that a well-distributed, dense (several hundred observations per 5° latitude-longitude block) subset providing global coverage, was obtained. Although no such screening was required for the COSMOS-49 data, obtained during a period of minimal solar activity and at low altitude (254-484 km), the satellite's eleven-day lifetime provided less dense (7-20 observations per 5° latitude-longitude block) coverage up to latitude limits of ±50 degrees.

The method utilized to determine an anomaly is a regional-residual separation where the regional field is defined by a four-dimensional function ($f(\phi, \theta, r, t)$). This function is computed by least squares fitting of a spherical harmonic series to the observed data. The series is truncated either at a harmonic order where the root mean square of the fit does not decrease significantly by computing higher order coefficients or at some prior arbitrary point. The anomalies or residuals, termed ΔF, are defined as the difference between the measured and computed values at each observation. The method of presenting the residuals in this paper is by averaging the ΔF values over 5° longitude-latitude blocks.

COSMOS-49 DATA

Recently, Benkova [4] reported a residual analysis of the COSMOS-49 data. Using the IZMIRAN "COSMOS-49" field model with an $n^* = 9$, residual values were computed for 5° latitude-longitude blocks. Use of the POGO (3/68) and COSMOS (9/68) [5] reference fields did not significantly affect the results.

Also, any effects attributable to external fields and satellite position errors were examined and dismissed. Thus, the map is presented as a valid representation of the anomalous field at COSMOS-49 altitudes (mean ≈ 375 km).

A duplication of their calculations using the COSMOS (9/68) field model is shown in Figure 1. The predominant anomalies were termed "intermediate size" anomalies and postulated to have a crustal and/or upper mantle origin. "Intermediate size" is the term chosen to distinguish between their definition of crustal (10-20 km wavelength) and core anomalies.

OGO-2, 4, 6 DATA

Analysis of the OGO-2, 4, 6 data provides an independent set of residual values that can be used to verify the existence of these "intermediate size" anomalies.

MODEL FIELD

Initially, a residual map obtained by subtracting the ninth and lower order harmonics from the $n^* = 11$ POGO (10/68) field model [5] was prepared (Figure 2). This figure represents a smoothed anomalous field containing only harmonics of orders ten and eleven. These anomalies with wavelengths of approximately 4000 km, are similar to the "intermediate size" anomalies of the COSMOS-49 map (Figure 1). Although the POGO (10/68) residual map is much smoother, the two figures appear quite similar and their agreement was investigated statistically.

The cross correlation function calculated had a maximum value of 0.45 at 0, 0 lag in latitude, longitude. However, analysis of the power spectrum revealed that the predominant power in the COSMOS-49 residual map is in the frequency band of the tenth and eleventh harmonic. This was determined by analysis of the individual power spectra and confirmed by calculation of the coherence function. Thus, signals with wavelengths of the order of 4000 km are present in both data sets and the low correlation value is undoubtedly affected by the additional higher frequency content of the COSMOS-49 residuals.

OGO-2, 4, 6 RESIDUALS

Recently, we have been able to produce a 5 degree residual map from the POGO measurements. A data set of POGO measurements taken at times when Kp (Geomagnetic Planetary Index) was less than 0^+ was compiled by R. A. Langel and R. E. Sweeney at Goddard Space Flight Center. Further refinement of the data set was obtained by visual examination of magnetograms to assure that only undisturbed data were selected. Then, a special field model with $n^* = 9$ was fit to these data.

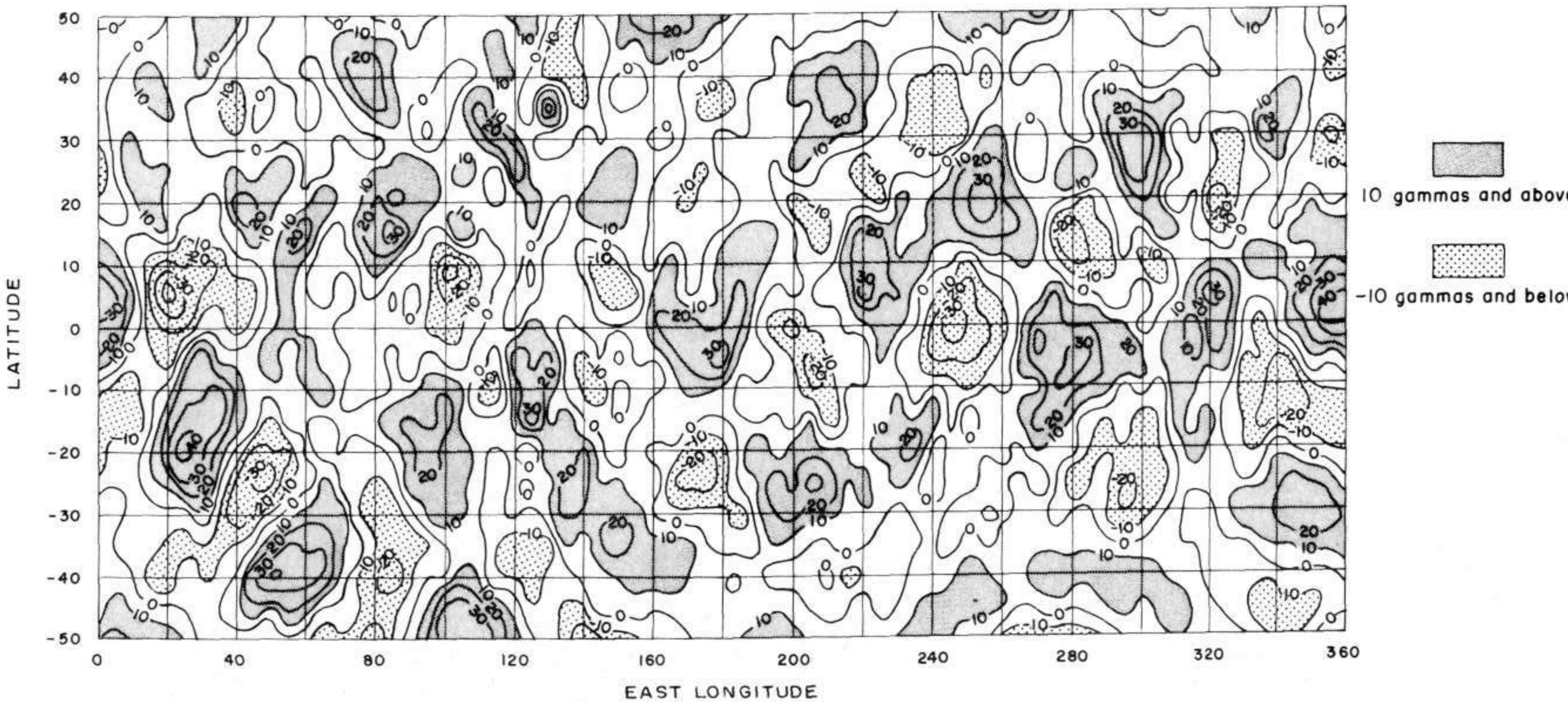

Figure 1. COSMOS-49 residuals, averaged over 5-degree squares. Contour Interval: 10 gammas.

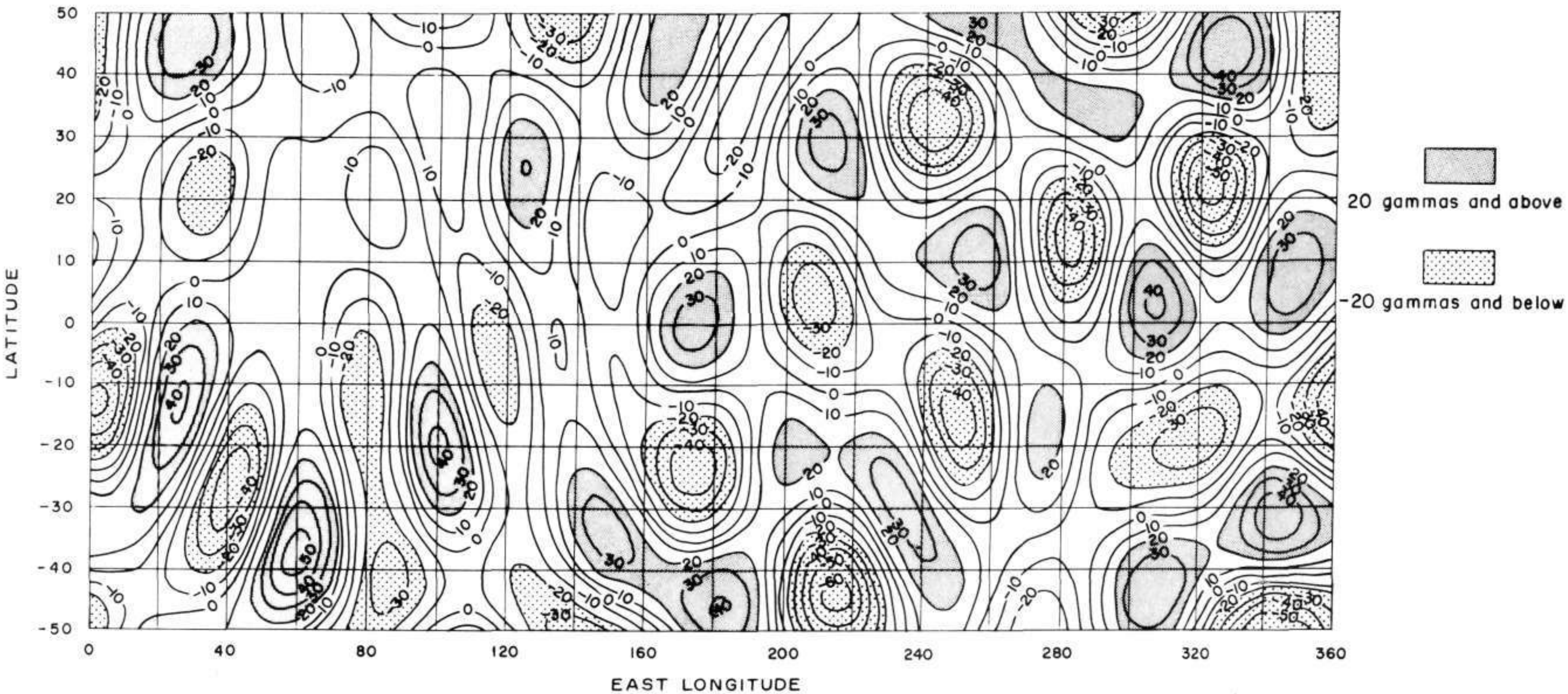

Figure 2. POGO (10/68) Field, (n* = 11) - (n* = 9) Contour Interval: 10 gammas.

A subset of these data was compiled by selecting observations made at altitudes less than 700 km and at latitudes less than ±50°. Residuals of this subset were then calculated using the special field model and are presented in Figure 3 (and also Figure 3a with continental outlines). The similarity between the residuals of this data set with a mean elevation of 507 km and those of the COSMOS-49 data (Figure 1) is quite striking. The difference in frequency content between the two maps (Figures 1, 3) is generally what would be expected in observations of the same source field taken at different elevations. The overall similarity of the two maps not only confirms the presence of the "intermediate size" anomalies but also the other anomalies of the COSMOS-49 map.

CONCLUSIONS

Thus the existence of the "intermediate size" anomalies reported by Benkova [4] is confirmed by an analysis of a completely independent data set. The main point of this paper has been to demonstrate the existence of these anomalies. At this stage any comment on their origin would be premature. However, by considering them to be described by the tenth harmonic, an estimate of the magnetic intensity of the source relative to the detected anomalies can be calculated. A source at the mantle-core boundary would require an amplitude 3000 times these anomaly values whereas a crustal and/or mantle source only twice these amplitudes.

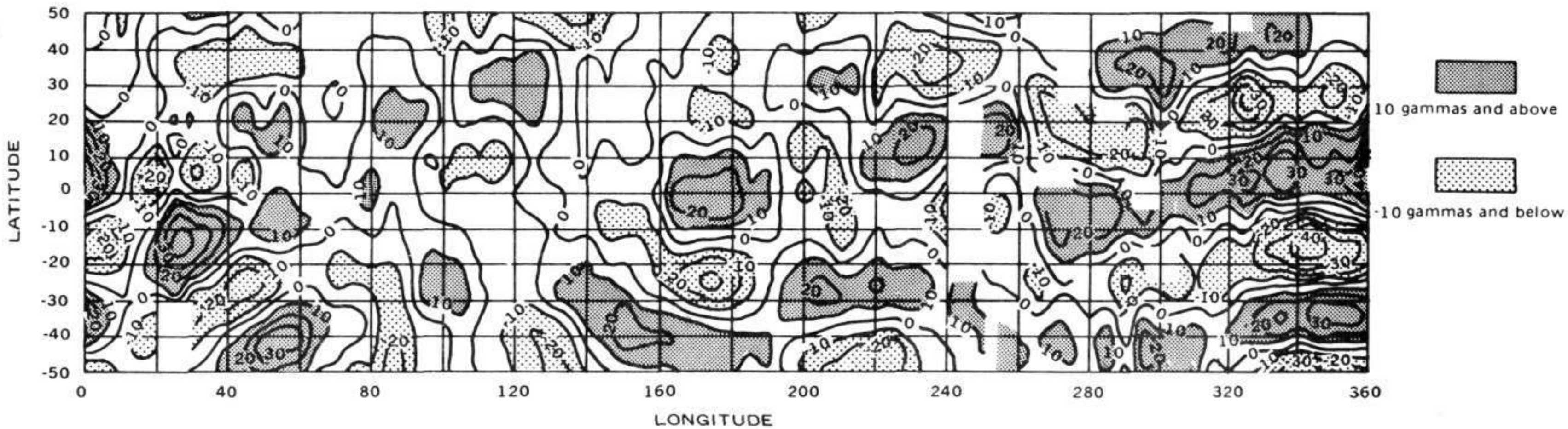

Figure 3. POGO residuals, averaged over 5-degree squares. Contour Interval: 10 gammas.

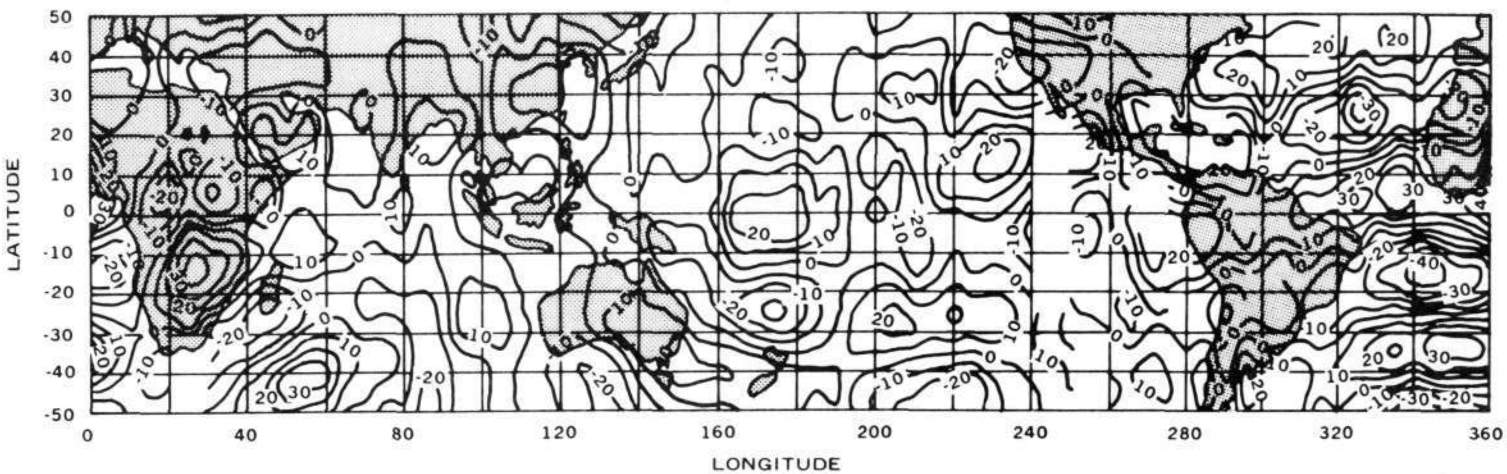

Figure 3a. POGO residuals, averaged over 5-degree squares (with continental outlines).
Contour Interval: 10 gammas

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